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(56) Documents Cited
WO 97/18606 A **US 5764675 A** **US 5309457 A**
US 5253260 A **US 5107091 A** **US 5105429 A**
US 5031184 A

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UK CL (Edition P) **H1C CA CF , H1K KEAP KPADL KPDA KPDB KPDX**
INT CL^6 **H01L 25/075 25/13 27/15 33/00 , H01S 3/04 3/042 3/043 3/23 3/25**
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(54) Abstract Title
A semiconductor laser diode bar assembly

(57) A semiconductor laser diode bar assembly comprises a plurality of sub-assemblies 1a,1b each including a copper base plate 2a,2b in which is mounted a plurality of heat pipes 3, for distributing heat within the base plate from a region under a diode bar 4a,4b mounted to the base plate. The sub-assemblies 1a,1b are releasably mounted on a common heat sink 7 and may be electrically isolated from said heat sink by electrically insulating layer 11. Incorporation of the heat pipes into the base plate of each sub-assembly, which base plate forms an electrode for the diode bar, results in more efficient cooling of the diode bar 4. The other electrode of the diode bar may be provided by a conductive layer 6. The heart sink 7 may include a Peltier cooling device and a thermocouple.

Fig.1B.

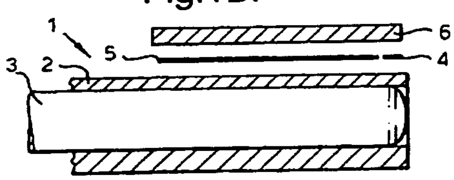
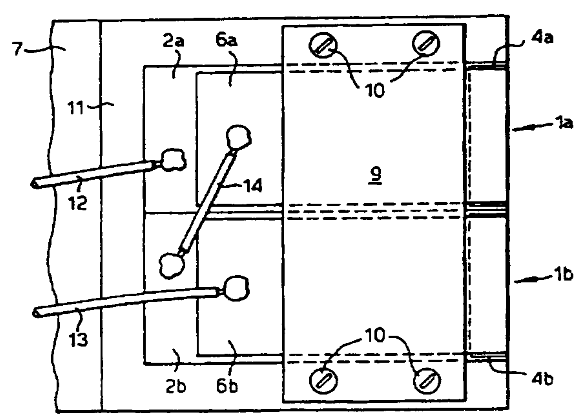


Fig.2B.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1A.

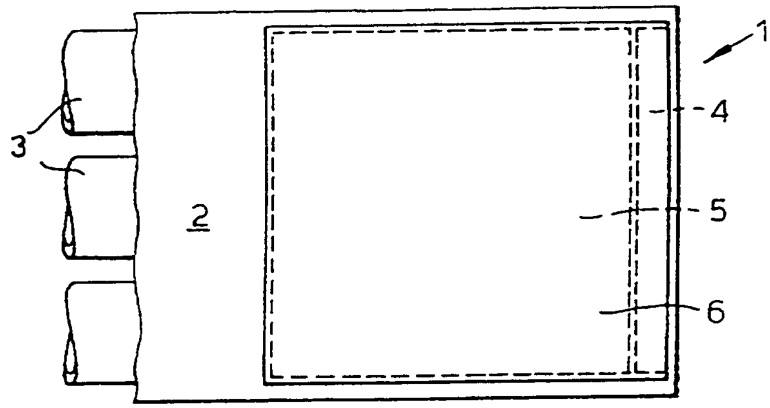


Fig.1B.

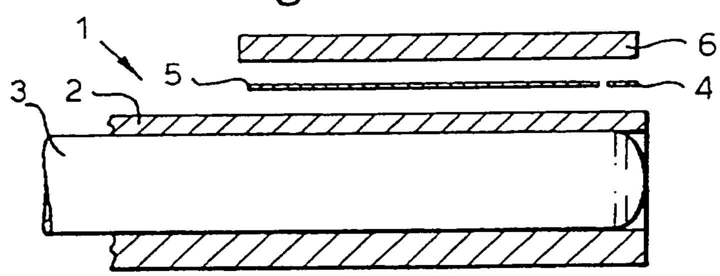


Fig.1C.

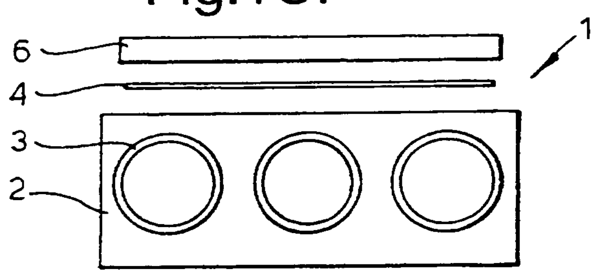


Fig.1D.

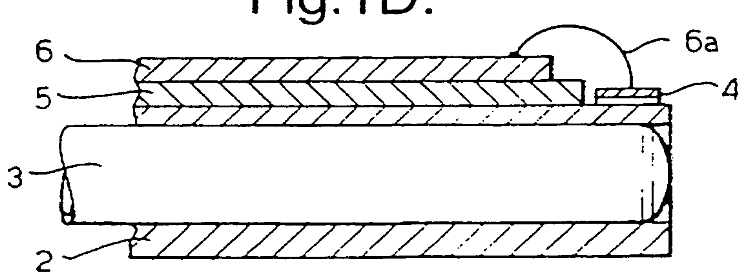


Fig.2A.

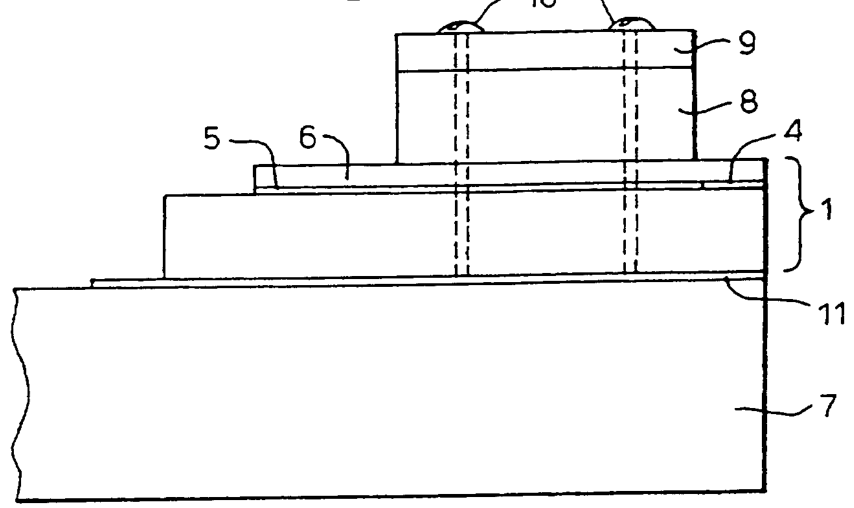
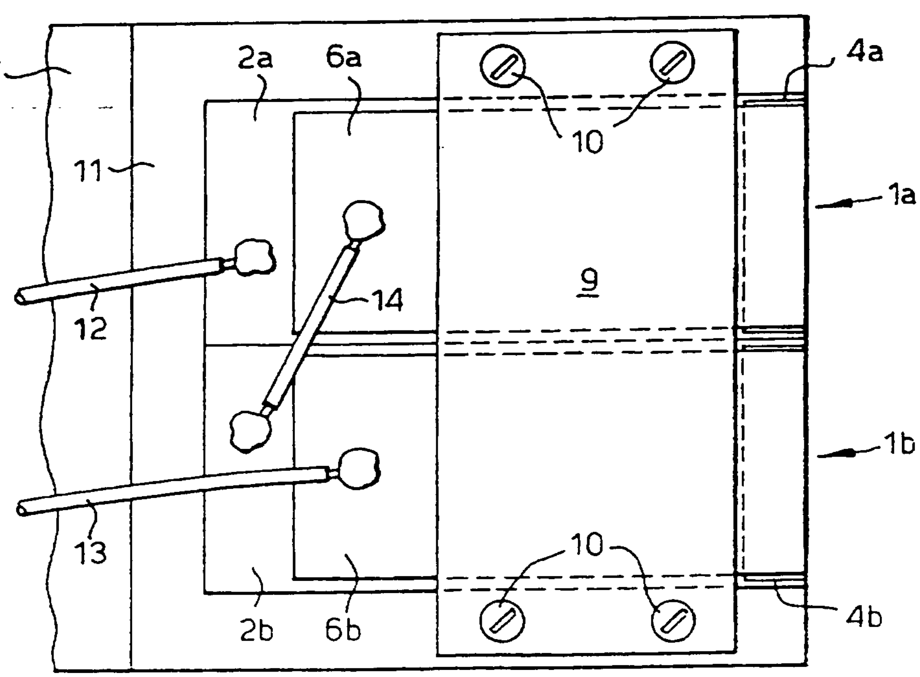


Fig.2B.



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A SEMICONDUCTOR LASER DIODE BAR ASSEMBLY

The present invention relates to a semiconductor laser diode bar assembly for pumping a laser cavity.

In order to efficiently pump a laser cavity, the laser diode bar must operate at a specified frequency. This frequency is temperature dependent and therefore the diode bar must be maintained at a constant specified operating temperature, a typical requirement may be for the diode bar to operate at $55 \pm 1\,^{\circ}C$.

The requirement that the temperature of the diode bar be kept at a relatively low constant temperature is particularly problematic because of the small size of the diode bar usually employed. In some applications a footprint area of the diode bar may be as small as 20 mm^2 and yet produce 100 W of heat. A further complication arises from the requirement that the diode bar be substantially distortion-free in order to avoid alignment problems and this normally precludes sandwiching the diode bar between two heat sinks.

In addition to the above, a significant electrical power supply is required for the diode bar and therefore substantial electrodes have to be applied to opposite surfaces of the diode bar. Because diode bars form part of an electrical circuit powering them they must be electrically insulated from any electrically conductive heat sink, resulting in a multi-layer device where each interface provides a potential thermal barrier.

A further complication arises in many applications where a compact design is required, which normally necessitates cooling by Peltier devices in order to avoid the complications with having a fluid-cooled heat sink, but which also require the diode assembly to operate in ambient temperatures of up to 80°C. This poses design problems, for thermal boundaries between the diode bar and the heat sink may typically result in the heat sink having to be maintained at a temperature of about 10°C requiring excessively large and efficient Peltier devices to maintain a heat sink at such temperatures in an ambient environment which is at 80°C. The problem is further compounded by the heat being generated in such a small area, resulting in it being difficult to distribute that heat to the operating surfaces of large area Peltier devices. The further the distance from the diode, the lower the operating temperature of the Peltier device required because of the extended thermal gradient.

According to the present invention there is provided a heat sink and a plurality of sub assemblies releasably attached thereto, each sub assembly comprising an electrically and thermally conductive base plate and a solid state laser diode bar attached to the base plate, the base plate forming a first electrode of the diode bar and having at least one heat pipe incorporated therein.

In previous designs the objective has been to minimise the separation between a heat sink and the diode bar heat source, in order to minimise the thermal gradient. A copper base plate has therefore been used having a minimum thickness sufficient to provide the required rigidity for the diode bar. This base plate, with the diode bar and

other integers of the diode bar assembly attached, is then mounted on the heat sink with a thin layer of diamond positioned between the copper base plate and the heat sink. The diamond layer electrically insulates the base plate from the heat sink, which base plate forms a first electrode of the diode bar. The inventor has realised that having a relatively thick base plate and incorporating heat pipes within the base plate, which can be 200 to 300 times more thermally conductive than copper, then the heat generated by the diode bar can be dispersed over a relatively large area without creating a large thermal gradient. Because of the larger area in contact with the heat sink the energy density at the interface is less, enabling the heat sink to be maintained at a higher temperature whilst maintaining the diode bar at the required operating temperature. Also because each base plate is relatively thick the sub assemblies can be releasably mounted on the heat sink so that any failed diode bar can be replaced with its associated sub assembly. Furthermore where a diamond insulating layer between the base plate and the heat sink would normally be required this can be substituted for a slightly less thermally conductive, but considerably cheaper material such as silver loaded rubber.

Preferably the assembly further comprises an insulating layer positioned on the base plate, behind the diode bar, and an electrically conductive layer on top of said insulating layer, the electrically conductive layer extending over and being in electrical contact with the diode bar to form a second electrode of the diode bar. The conductive layers forming the first and second electrodes need not extend over the whole width of the assembly, neither do they have to be formed by vapour deposition, for such

layers could be of a suitable foil material or sheet.

One embodiment of the present invention will now be described by way of example only with reference to the accompanying figures, in which like numerals are used to indicate like parts, and in which:

Figure 1A is a partly cut away plan view of a semi-conductor laser diode assembly in accordance with the present invention; and

Figures 1B and Figure 1C are side and front elevations respectively of the assembly of Figure 1;

Figure 2A is a side elevation of the assembly of Figure 1A mounted on a heat sink; and

Figure 2B is a plan view of the arrangement of Figure 2A.

Referring to Figures 1A, 1B and 1C, the assembly indicated generally as 1 comprises a copper base plate 2 in which are embedded heat pipes 3. These are inserted in cylindrical bores within the base plate 2 and are bonded in place with silver loaded epoxy or low temperature solder ensuring good thermal contact with the copper of the base plate 2. The base plate 2 is 4 mm deep and the diameter of the heat pipe is 3 mm. (Each heat pipe comprises a cylindrical housing sealed at each end which is filled with water and water vapour).

A Semiconductor diode bar 4 flashed on both sides with nickel is soldered to the upper surface of the base plate 2 with a higher temperature solder, (in Figures 1B and 1C the

various components are shown separated for clarity). Also secured to the upper surface of the base plate 2 is an electrical insulator 5 which may be bonded in place by a suitable adhesive. The insulator is the same thickness as the diode bar 4 in its assembled condition, typically 0.1 mm, and provides a flush upper surface on which a conductive layer 6 of copper is placed. This conductive layer 6 is soldered with an indium based solder to the diode bar 4 and provides a second electrode to the diode bar, the base plate 2 providing the first electrode. An alternative arrangement is illustrated in Figure 10 where the conductive layer 6 terminates before the diode bar 4, with electrical connection being made by an array of wires 6a along the bars length, only one of which is shown, attached to a layer of gold or indium on the upper surface of the bar 4, which forms an upper electrode.

Referring now to Figures 2A and 2B, the assembly of Figure 1 is shown mounted on a heat sink 7. The heat sink 7 comprises a Peltier cooling device and a thermo-couple (not shown) arranged to maintain the heat sink at a desired temperature. The assembly 1 has deposited on its upper surface a layer of compliant material 8 such as silicone and is sandwiched between the upper surface of the heat sink 7 and a clamping bar 9, by means of screws 10. The base plate 2 of the assembly is electrically insulated from the metallic heat sink 7 by insulating layer 11.

Referring to Figure 2B it can be seen that two assemblies, 1a and 1b, are mounted on the heat sink 7 such that the respective diode bars of each device 4a and 4b are arranged side by side. This provides, in effect, a diode bar twice the length of that

available as a single unit. Conductors 12, 13 and 14 are connected to the respective first and second electrodes as shown such that the diode bars are electrically connected in a series thereby ensuring uniform operation.

The above describes one embodiment of the present invention. However other arrangements within the scope of the appended claims may occur to a person skilled in the art.

CLAIMS

1. A Semiconductor laser diode bar assembly comprising a heat sink and a plurality of sub assemblies releasably attached thereto, each sub assembly comprising an electrically and thermally conductive base plate and a solid state laser diode bar attached to the base plate, the base plate forming a first electrode of the diode bar and having at least one heat pipe incorporated therein.

2. An assembly, as claimed in claim 1 wherein the sub assemblies are mounted on a substantially planar surface of the heat sink.

3. An assembly as claimed in claim 1 or 2 wherein the sub assemblies are arranged such that light emitting faces of their respective diode bars form a long linear array.

4. An assembly as claimed in any preceding claim further comprising a thermally conductive electrically insulating layer arranged between each base plate and the heat sink.

5. An assembly as claimed in any preceding claim wherein each sub assembly further comprises an insulating layer positioned on the base layer behind the diode bar and an electrically conductive layer on top of said insulating layer,

the electrically conductive layer extending over and being in electrical contact with the diode bar to form a second electrode of the diode bar.

6. An assembly as claimed in any one of claims 3 to 5 wherein the heat sink is arranged to be maintained at a constant temperature.

7. An assembly as claimed in any preceding claims wherein the heat pipes are inserted in bores in respective base plates.

8. An assembly substantially as hereinbefore described with reference to, and/or as illustrated in, the accompanying drawings.

The Patent Office

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INVESTOR IN PEOPLE

Application No:	GB 9819708.0	**Examiner:**	Martyn Dixon
Claims searched:	all	**Date of search:**	4 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1K (KEAP,KPADL,KPDA,KPDB,KPDX); H1C (CA,CF)

Int Cl (Ed.6): H01L (25/075,25/13,27/15,33/00); H01S (3/04,3/042,3/043,3/23,3/25)

Other: Online: EPODOC,WPI,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	WO 97/18606 A	(Commissariat a l'Energie Atomique)	1
A,P	US 5764675 A	(Juhala)	1
A	US 5309457 A	(Minch) see e.g. figs 2,3,6,9	1
A	US 5253260 A	(Hughes) see e.g. figs 2,6,7	1
A	US 5107091 A	(Applied Solar Energy)	1
A	US 5105429 A	(USA) see fig 2	1
A	US 5031184 A	(Carl-Zeiss-Stiftung) see e.g. figs 1-3 and col 3, lines 7-11	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.